TRILITHIC **Application Note**

VoIP RF Impairments

Voice Quality Correlation with RF Impairments

Telephony quality begins with physical media. For cable systems, the medium is the HFC plant that carries analog and digital information to network interface. Impairments that adversely affect CNR and the presence of intermodulation distortion (CSO and CTB) have the same effect on digital information as on analog signals. The damage done by changing data bit representations on an analog carrier is cumulative. Exceeding a packet loss threshold first garbles and then completely interrupts a voice conversation. Packet loss should not exceed 0.1 to 0.5 percent for VoIP and no more than 1 percent for high speed data.

DOCSIS 2.0 Guidelines on Physical Impairments

Downstream:

- Cable system normal downstream operating frequency range is from 50 MHz to as high as 860 MHz; however the values in this table apply only at frequencies of 88 MHz
- RF channel spacing (design bandwidth): 6 MHz
- Transit delay from head-end to most distant customer: 0.800 msec (typically much less)
- Carrier-to-noise ratio in a 6 MHz band: 35 dB
- Carrier-to-composite triple beat distortion ratio: 41 dB
- Carrier-to-composite second order distortion ratio: 41 dB
- Carrier-to-cross-modulation ratio: 41 dB
- Carrier-to-any other discrete interference (ingress): 41 dB
- Amplitude ripple: 3 dB within the design bandwidth
- Group delay ripple in the spectrum occupied by the CMTS: 75 ns within the design bandwidth
- Micro-reflections bound for dominant echo
    - -20 dBc @ l.5 µsec; -30 dBc @ >1.5 µsec
    - -10 dBc @ 0.5 µsec; -15 dBc @ 1.0 µsec
- Carrier hum modulation: not greater than -26 dBc (5%)
- Burst noise: not longer than 25 µsec at a 10 Hz average rate
- Maximum analog video carrier level at the CM input: 17 dBmV
- Maximum number of analog carriers: 121

Upstream:

- Frequency range: 5 to 42 MHz edge to edge
- Transit delay from the most distant CM to the nearest CM or CMTS: 0.800 msec (typically much less)
- Carrier-to-interference plus ingress ratio: 25 dB
    - Sum of noise, distortion, common-path distortion, cross-modulation and the sum of discrete and broadband ingress signals:
- Carrier hum modulation: -23 dBc (7.0%)
- Burst noise: not longer than 10 µsec at a 1 kHz average rate for most cases
- Amplitude ripple 5 to 42 MHz: 0.5 dB/MHz
- Group delay ripple: 5 to 42 MHz: 200 ns/MHz
- Micro-reflections (single echo)
    - -10 dBc @ 0.5 µsec
    - -20 dBc @ 1.0 µsec
    - -30 dBc @ >1.0 µsec
- Seasonal and diurnal reverse gain (loss) variation:14 dB min to max

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Trilithic Applications Engineering
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In the headend, MER is essentially as high as the QAM analyzer is capable of measuring. This means that when setting the up-converter input and output levels, one must monitor not only the amplitude of the digitally modulated signal, but also the pre- and post-FEC BER, MER and observe the constellation for signs of impairment. In the headend, look at the signal sources closely; one device that might be a problem is the up-converter. Some older up-converters do not work as well with 256 QAM as well as they do with 64 QAM, requiring more careful setup of IF input and RF output levels. The IF input and RF output levels must be set carefully within a very tight window, on the order of 1 to 2 dB. Outside of the correct range, pre-FEC errors become noticeable. Most new designs of up-converters do not exhibit this characteristic.

NOTE: The signal will degrade as you go farther into the system. Below is a typical chart for VoIP.

	MER		BER	
	64 QAM	**256 QAM**	**Pre-FEC**	**Post-FEC**
Headend				
Excellent	40 dB	40 dB	1×10^{-9}	1×10^{-9}
Acceptable	37 dB	38 dB	1×10^{-9}	1×10^{-9}
Node				
Excellent	37 dB	38 dB	1×10^{-9}	1×10^{-9}
Acceptable	35 dB	36 dB	1×10^{-9}	1×10^{-9}
Amp				
Excellent	35 dB	38 dB	1×10^{-9}	1×10^{-9}
Acceptable	33 dB	35 dB	1×10^{-8}	1×10^{-9}
Tap				
Excellent	34 dB	37 dB	1×10^{-9}	1×10^{-9}
Acceptable	32 dB	34 dB	1×10^{-8}	1×10^{-9}
CM				
Excellent	33 dB	36 dB	1×10^{-8}	1×10^{-9}
Acceptable	32 dB	33 dB	1×10^{-7}	1×10^{-9}

NOTE: The 860 DSP can measure BER in the BER mode for up to 10 minutes.
NOTE: The 8821Q can measure BER in the statistics mode for up to 72 hours.

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